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Lewis Research Center

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Insulating Effectiveness of Self-Spacing Dimpled Foil

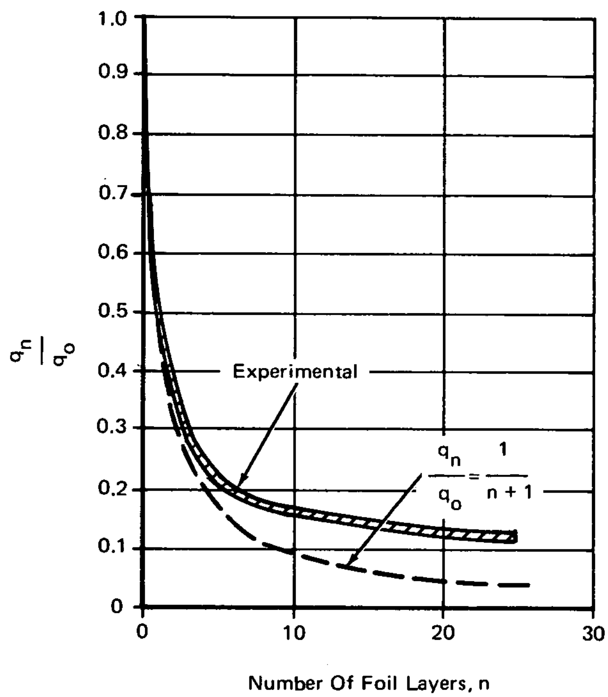
Multiple layers of self-spacing, dimpled metallic foils are frequently employed as insulation to inhibit heat transfer by thermal radiation in vacuum environments. Generally, data have not been available on the insulating effectiveness of these foils as a function of temperature and the number of layers of foil. Insulation effectiveness is usually estimated on the basis of theory and offsetting assumptions. Experimental data have now been obtained for a particular design of these foils which permit more accurate estimation of insulation effectiveness.

Conventional estimates of the insulating effectiveness of multiple layers of metallic foil in vacuum are based on the expression:

$$\frac{q_n}{q_o} = \frac{1}{n+1}$$

where q_n is the heat flux radiated by the insulated plane surface, q_o is the heat flux radiated by the uninsulated surface, and n is the number of layers of foil. This equation assumes that the layers of foil do not touch (hence there is no heat transfer by conduction) and, also, that the surfaces have an emissivity of one. Neither assumption is valid in practice. Adjacent foil layers do touch; conduction occurs; and surfaces do not have emissivities of one. However, it has been further assumed that these effects are offsetting, and hence the equation can be used to estimate the number of layers of foil required for a given situation.

An experiment has been conducted to determine the actual heat losses as a function of the number of foil layers. The foil investigated was 0.0051 cm thick columbium, 1-percent zirconium refractory alloy material mechanically dimpled to a height (excluding the foil thickness) of about 0.0254 cm with approximately 28 dimples/cm^2 on a triangular pitch. The purpose of this dimpling was to minimize contact between adjacent foil layers and, hence, minimize thermal conduction. Stainless-steel-sheathed electrical heaters were wrapped with 5, 15, and 25 layers of this foil; a similar heater was left uninsulated for comparison. The heat losses from the insulated heaters were determined in a vacuum of 10^{-7} Torr at heater surface temperatures in the range of 700 to 1089K. These losses were compared to the heat radiated from the bare heater at the same surface temperatures. The insulation effectiveness data obtained are shown in the figure in comparison with the theoretical values from the equation:



DIMPLED FOIL THERMAL RADIATION HEAT LOSS DATA

$$\frac{q_n}{q_o} = \frac{1}{n+1}$$

(continued overleaf)

As shown, the measured heat losses through the dimpled foil are greater than those predicted by the equation. This characteristic, and the fact that layers of foil beyond 10 do not further reduce the heat loss, suggest that thermal conduction may be an important factor in the performance of this insulation.

The curve for the experimental data can be employed to estimate the number of foil layers of the type tested to achieve a particular reduction in radiation heat loss for the range of temperatures investigated. The experimental data can also be used as a guide in more accurate estimates of the performance of multiple layers of other types of foil that are of similar construction.

Note:

No further documentation is available. Specific questions, however, may be directed to:

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No patent action is contemplated by NASA.

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